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Rare Earth Elements: Tracers of natural and anthropogenic processes along the continent-ocean continuum. 2022 Gast Lecture

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Rare Earth Elements (REE) have moved into the spotlight of geopolitics and media attention in the past decades. Their application in several high-technology sectors (green energy, medicine, defense, and nuclear industries) created a strongly increasing demand for REE. The production increased manifold, and the trend appears to be for a continued expansion in the REE use, to which the dominant producers responded with price hikes and export restrictions. As such, the REE are vital examples of technology-critical metals. The increasing consumption of high-tech products is followed by the increase of anthropogenic REE releases into the environment. Still, the impact of anthropogenic activities on REE cycling remains widely unknown.

The REE distribution in the environment is controlled by their input, removal, transport, and biogeochemical cycling. Untangling these various processes to understand their cycles is now a major question in marine geochemistry. Such understanding is an absolute requirement if we are to predict future changes along the land-ocean continuum due to natural or anthropogenic drivers such as pollution and climate change. Such drivers may alter REE cycles and, potentially, their mobility, availability, uptake by biota, ecotoxicity, and therefore ecosystem services and human health.

Among the REE, the anthropogenic gadolinium (Gd) is the most widespread contaminant, almost omnipresent in rivers, coastal waters, groundwater, and even drinking water. Complexes of Gd, the primary source of anthropogenic Gd, are used to enhance contrast in magnetic resonance imaging diagnostics. Due to their extreme stability, they are rapidly renally excreted, cannot be removed from sewage in wastewater treatment plants, and, therefore, enter the environment. Thus, leading to substantial anomalies in normalized REE patterns, as well as making their way into the biota, indicating that at least some portion of the Gd complexes is bioavailable. A recent study showed that Gd complexes are also bioaccessible to humans. By combining measurements of the REE in several matrices and their use as tracers of natural and anthropogenic processes, I will discuss the drivers that affect REE and set this in the context of REE cycling and the potential implications for ecosystems and human well-being.